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DEPARTMENT OF WATER RESOURCES
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SHASTA VALLEY WATER QUALITY LITERATURE REVIEW

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INTRODUCTION

The Department of Water Resources (DWR) has responsibility to insure that adequate supplies of water suitable for all beneficial uses is available for both current and future needs. The Department and other agencies have collected water quality information on the Shasta Valley for over 50 years. The purpose of this report is to review this available data and literature pertaining to water quality in the Shasta Valley. This report identifies locations where water quality impairments produce conditions unsuitable for beneficial uses. This report also identifies those situations where the current data is inadequate to assess surface or ground water suitability for beneficial use.

The Shasta Valley is in central Siskiyou County (Figure 1). Shasta Valley is elliptical in shape with the major axis lying in a north-south direction (DWR 1964). The valley is 36 miles long and 30 miles wide at its widest point. Shasta Valley contains 507,000 acres of which 141,000 acres are irrigable lands (DWR 1964).

Glacial melting on Mount Shasta and mountain precipitation are the principal sources of recharge for the Shasta River. Much of this recharge reaches the river through underground flow (DWR 1961). The Shasta River originates in the higher elevations of the Eddy's southwest of the Shasta Valley and flows northward to join with springs from underground flow from Mount Shasta in the vicinity of Big Springs. The river flows north through the Shasta Valley to Yreka before entering a steep seven mile long canyon leading to the Klamath River. The Little Shasta River originates in the Cascade Range near Goosenest and flows westward to join the Shasta River about two miles south of Montague. Several minor tributaries originate in the mountains along the west side of Shasta Valley. These streams are generally short, steep and drain areas of impervious rock. Most of these tributaries are ephemeral.

Agriculture is the major land use within the valley. However, local spring flooding and a short-growing season restrict the type of crops produced to pasture, alfalfa, small grains and a very limited selection of field crops.

A single large storage reservoir, Lake Shastina, with a useable storage capacity of about 50,000 acre-feet, has been in operation on the Shasta River since 1928. This reservoir supplies water through a 20-mile long canal to Little Shasta Valley and the northeastern portion of Shasta Valley.

The North Coast Regional Water Quality Control Plan (1989) identifies beneficial uses of water within the Shasta Valley as municipal and domestic supply, agricultural supply, freshwater replenishment, warm freshwater habitat, cold freshwater habitat, wildlife habitat, fish migration, and spawning habitat. To protect these beneficial uses, the Regional Water Quality Control Board has adopted specific water quality objectives for the Shasta Valley (Table 1).

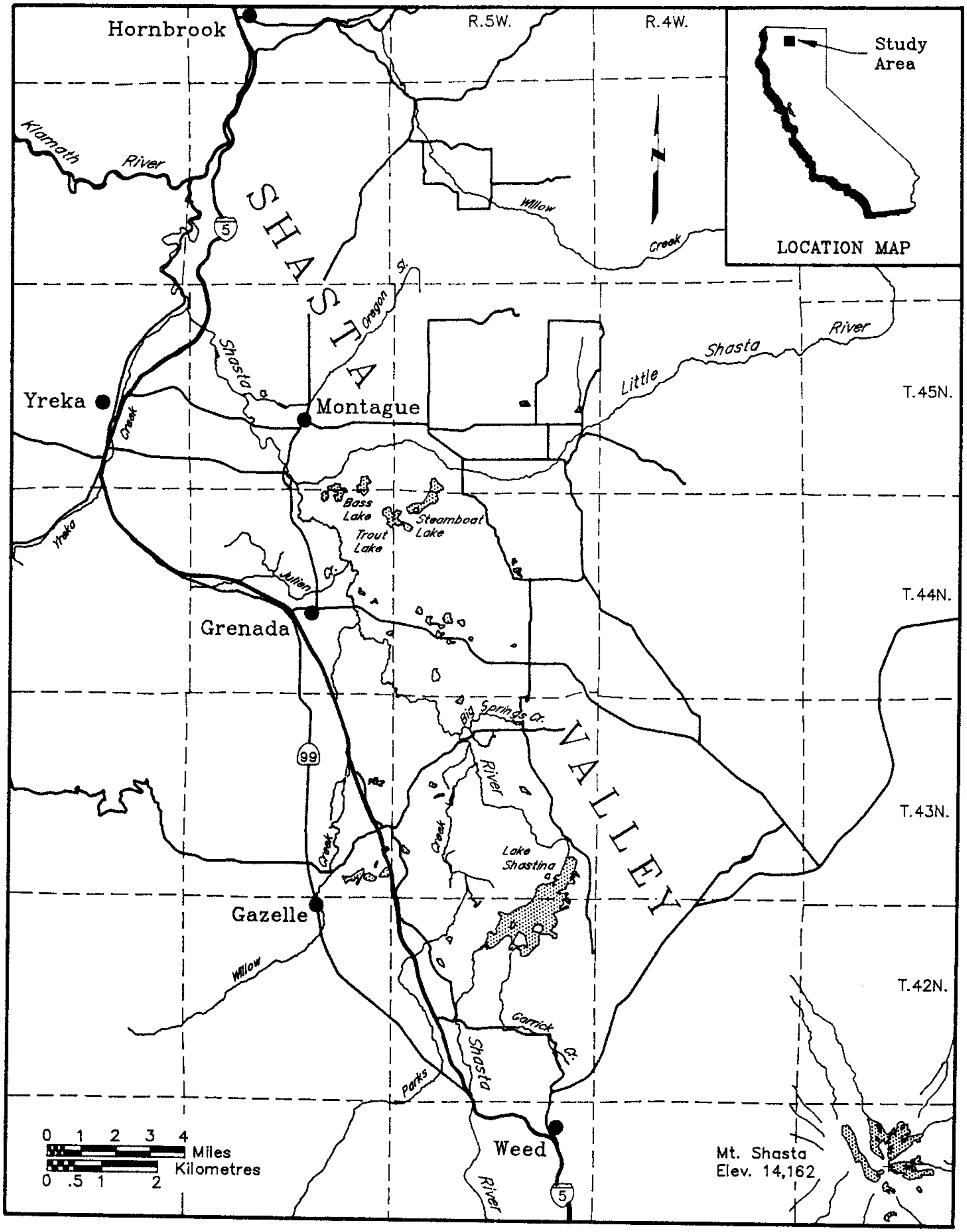

Figure 1. Location of the Shasta Valley.

GROUND WATER

Water quality sampling has been conducted on a large number of domestic and irrigation wells within the Shasta Valley. Water Data Information System (WDIS) records contain water quality information on over 100 wells. Less than half of these wells have been sampled in the last 25 years. The Department of Water Resources (DWR) annually collects water quality information from a set

Water Quality Objectives for the Shasta Valley

Table 1

	Source			
Parameter	Shasta River	Other Streams	Lake Shastina	Ground Water
Electrical conductivity (micromohs/cm)	800	700	300	800
dissolved oxygen (mg/L)[1/]	7.0	7.0	6.0	---
pH[2/]	7.0-8.5	7.0-8.5	7.0-8.5	7.0-8.5
Hardness (mg/L)	220	200	120	180
Boron (mg/L)	1.0	0.5	0.4	1.0
Fluoride (mg/L)[3/]	1.4-2.4	1.4-2.4	1.4-2.4	1.4-2.4
Arsenic (mg/L)	0.05	0.05	0.05	0.05
Barium (mg/L)	1.0	1.0	1.0	1.0
Cadmium (mg/L)	0.01	0.01	0.01	0.01
Chromium (mg/L)	0.05	0.05	0.05	0.05
Lead (mg/L)	0.05	0.05	0.05	0.05
Mercury (mg/L)	0.002	0.002	0.002	0.002
Nitrate (mg/L)	45	45	45	45
Selenium (mg/L)	0.01	0.01	0.01	0.01
Silver (mg/L)	0.05	0.05	0.05	0.05
Endrin (mg/L)	0.002	0.002	0.002	0.002
Lindane (mg/L)	0.004	0.004	0.004	0.004
Methoxychlor (mg/L)	0.1	0.1	0.1	0.1
Toxaphene (mg/L)	0.005	0.005	0.005	0.005
2,4 D (mg/L)	0.1	0.1	0.1	0.1
2,4,5 TR Silver (mg/L)	0.01	0.01	0.01	0.01

1/ Minimum concentration
2/ Range of acceptable values
3/ Temperature dependent

of 18 wells within the Shasta Valley. The United States Geological Survey (USGS) sampled water quality at seventy-eight wells prior to 1960. No ground water quality data have been collected by the USGS within the Shasta Valley since 1960.

Physical Ground Water Characteristics

Extensive physical water quality data for ground water in the Shasta Valley have been collected. Paramenters monitored include temperature, pH electrical conductivity, and alkalinity.

Temperature records of ground water are difficult to interpret. Holding tanks, pipes, and other above ground systems can influence temperature and induce measurement error if the well is not pumped for an adequate period to insure that aquifer water is being sampled. Further solar heating may occur in irrigation systems. WDIS records indicate that over 49 percent of the ground water temperatures collected exceeded 60°F and 8 percent exceeded 70°F.

Shasta Valley ground water pH values generally range from 7.0 to 8.5 (DWR 1976). This range is acceptable for all current beneficial uses of ground water in the area.

Electrical conductivity (EC) levels, with a range of 400 to 700 μmhos/cm, are generally considered excellent for most beneficial uses. However two wells contained EC values above 2,000 μmhos/cm, with a maximum value of 7,400 μmhos/cm. EC levels above 2,0000 μmhos/cm in irrigation waters are of doubtful suitability for most crop species (Scofield 1935, Wilcox 1948). Levels above 3,000 μmhos/cm are unsuitable for irrigation (Ayers and Westcot 1976).

Alkalinity values in Shasta Valley ground water generally range from 200 to 400 mg/L as $CaCO_3$. The maximum alkalinity value recorded was 1,200 mg/L as $CaCO_3$.

Mineral Quality

Over 500 mineral analyses of Shasta Valley ground water have been conducted. Local geology influences the mineral quality. Ground waters derived from serpentine areas contain magnesium as the dominant cation with a high percent of silica. Ground waters obtained from limestone formations contain calcium as the dominant cation. Waters obtained from volcanic formations contain high salinity, sodium, silica and boron (USGS 1960). Due to the influence of local geology, the ground waters of Shasta Valley can best be described as bicarbonate in character without a dominant cation (DWR 1976).

Shasta Valley ground waters are considered moderately hard to hard with values generally falling within the range of 100 to 200 mg/L as $CaCO_3$ (DWR 1976).

Total dissolved solids (TDS) concentrations vary widely, ranging from 91 to 4870 mg/L. Average values are normally within the range of 300 to 600 mg/L (DWR 1976). Four wells have been found with TDS values between 700 to 4,870 mg/L. TDS levels above 700 mg/L are unsuitable for irrigation of some crop species (Thorne and Peterson 1949). TDS levels above 2,100 are unsuitable for irrigation purposes (Scofield 1935).

Calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) concentrations are generally less than 50 mg/L. Three wells have been found with sodium concentrations in excess of 200 mg/L. The maximum sodium concentration recorded exceeded 1,700 mg/L. Sodium levels above 200 mg/L are not only toxic to plants but can also be deleterious to soil conditions (Wilcox 1948). Sodium may be harmful to persons suffering from cardiac, renal, and circulatory diseases at levels exceeding 200 mg/L.

Sulfate (SO_4), chloride (Cl), and nitrate (NO_3) levels found in Shasta Valley ground water are generally excellent for all beneficial uses. A single well contained SO_4 concentrations in excess of 200 mg/L. Sulfate levels above 200 mg/L can impact use for irrigation purposes (McKee and Wolf 1971).

Four wells contained chloride concentrations between 200 mg/L and 860 mg/L. Chloride levels above 200 mg/L may damage some sensitive crop species (Kelly 1941). Both alfalfa and potatoes are more sensitive to chloride than they are to sulfate concentrations.

Seven wells contained NO_3 levels between 45 and 81 mg/L. The EPA drinking water standard is 45 mg/L. Excessive NO_3 concentrations have been linked to increased risk of infant methemoglobinemia when high NO_3 waters are used to prepare baby formula. Approximately 29 percent of the domestic wells sampled in Montague contained NO_3 levels between 45 and 72 mg/L (DWR 1951). Septic system contamination of the ground water was considered the most likely source of the high NO_3 levels. Septic systems at Montagne were partially or entirely beneath the ground water level. Contamination of ground water by septic systems or municipal sewage treatment percolation beds was identified as a Shasta Valley ground water problem during two previous studies (DWR 1951, DWR 1960).

Boron concentrations above 0.75 mg/L can damage sensitive crop species during long-term irrigation. WDIS data indicate that about eight percent of the wells contain boron concentrations between 0.75 mg/L and 14.0 mg/L.

Most ground water mineral problems within the Shasta Valley are quite localized and stem from natural sources. Areas containing poor mineral quality are located: 1) along Oregon Slough and Little Shasta River; 2) in the vicinity of Montague; 3) between Grenada and Big Springs; and 4) in the Willow Creek drainage (DWR 1951, 1959, 1964). The Willow Creek and Julian Creek areas contain highly mineralized ground water of deep origin which is high in boron, TDS and sodium (DWR 1959). The Table Rock area contains springs which are high in boron, chloride and sodium (DWR 1959). These springs feed into both Oregon Slough and the Little Shasta River and are largely responsible for the high boron levels found in the lower Shasta River during periods of low flow.

<u>Nutrient Quality</u>

No ground water quality data involving nutrient analyses were found during this literature review.

Minor Element (Metal) Quality

WDIS records contain the results of minor element analyses on approximately 20 wells within the Shasta Valley.

Aluminum (Al), arsenic (As), chromium (Cr), cadmium (Cd), lead (Pb), mercury (Hg), selenium (Se) and silver (Ag) concentrations were found to be suitable for all beneficial uses.

Manganese concentrations were found at 0.08 mg/L in one well. Iron concentrations were found in two wells (0.31 mg/L and 1.6 mg/L). These levels are known to cause problems during laundry processing.

Copper (Cu) concentrations were found up to 0.39 mg/L in a single well. This copper concentration exceeds the threshold level for irrigation (0.1 mg/L) and freshwater aquatic life (0.02 mg/L) (McKee and Wolfe 1971).

Zinc (Zn) concentrations in excess of 0.09 mg/L were present in four wells. In soft water, zinc can be lethal to fish at concentrations ranging from 0.1 mg/L to 1.0 mg/L. The sensitivity to zinc varies with species age and condition. Only one of these four wells was used for irrigation purposes.

Toxic Substances

Pentachlorophenol contamination was discovered in a domestic well adjacent to and downgradient from the Hi-Ridge Lumber Mill near Weed (RWQCB 1990). No other toxic substance monitoring within Shasta Valley has apparently been conducted. Pesticide use in agricultural areas combined with the porus nature of some soils could lead to contamination of ground water aquifers in the Shasta Valley.

SURFACE WATER

Surface water quality data have been collected from at least 45 stations within the Shasta Valley. The vast majority of these data are physical water quality information. A substantial amount of mineral quality data have also been collected. Mineral quality information is generally adequate to allow assessment of suitability for irrigation purposes. Shasta Valley surface water suitability for other beneficial uses is based on much less information.

The "Shasta River near Yreka" monitoring station has been sampled monthly for 31 years and provides the best long-term surface water record in the Shasta Valley.

Almost all of the data reviewed was the result of grab sampling. Grab sample data is normally collected between the hours of 0600 to 1630 PST and does not present the diurnal fluctuation in water quality. Limited diurnal surface water quality sampling was conducted during 1971, 1972, 1973, 1981, 1982 and 1989.

Physical Water Quality

No specific temperature objectives were set in the Water Quality Control Plan (RWQCB 1989) for the Shasta Valley. However, discharges which elevate temperature into waters designated as "cold interstate waters" are prohibited. The Klamath River System, of which the Shasta River is a part, is designated as cold interstate water.

No continuous temperature records were discovered. Temperature data reviewed consisted primarily of monthly grab samples with limited diurnal data. Surface water temperatures found in the Shasta Valley were generally suitable for most beneficial uses. However, surface water temperatures may adversely impact cold freshwater habitat, fish migration and fish spawning uses. Shasta River surface temperatures infrequently exceed the lethal temperature of 77 to 78.5°F for rainbow trout (Oncorhynchus mykiss) and chinook salmon (Oncorhynchus tshawytscha). WDIS records indicate that about 2.5 percent of the temperature data collected at the Shasta River near Yreka station exceed 80°F. The maximum surface temperature recorded at this station exceeded 87°F (USGS 1970). The mean monthly maximum temperature at this station peaks in August at 75.2°F. Although these temperatures are high enough to adversely effect rainbow trout, chinook salmon do not enter the Shasta River until mid-September when stream temperatures normally begin to drop.

High fall temperatures can delay salmon migration. Adult immigrants exhibit poor survival when held at hatcheries at water temperatures greater than 60°F (DWR 1988). Adults held at water temperatures greater than 60°F also produce less viable eggs.

During May, stream temperature diurnal temperature fluctuations can exceed 9.0°F. Average winter and summer diurnal temperature fluctuations are 2 to 4°F and 4 to 8°F, respectively.

The effects of Shasta River stream temperatures on cold-freshwater habitat, fish spawning, and fish migration are unclear. The amount of water temperature change due to land and water use within the Shasta Valley also remains unquantified.

Dissolved oxygen concentrations fluctuate throughout the year was well as diurnally. The dissolved oxygen carrying capacity of water is regulated by temperature, salinity and pressure. Increasing temperature or TDS reduces the amount of dissolved oxygen which can be carried in water. Low dissolved oxygen concentrations can increase the toxicity of high levels of dissolved CO_2, ammonia, cyanides, zinc, lead, copper, and aerosols to aquatic biota. Dissolved oxygen levels alone can be lethal to trout if held for an extended period in waters containing less than 3.0 mg/L of dissolved oxygen.

Temperature affects not only the amount of oxygen which can be carried in water but also influences the rate of oxygen consumption. At higher temperatures, aquatic life consume greater amounts of dissolved oxygen during respiration.

The RWQCB objectives for the Shasta Valley surface waters specify a minimum dissolved oxygen content of 7.0 mg/L. The Shasta River and its tributaries frequently contain dissolved oxygen concentrations below 7.0 mg/L. Dissolved oxygen levels ranging from 1.7 to 3.9 mg/L were reported at the Shasta River below Shastina, at Highway 3, at Highway 96, and at the Montague-Grenada Road during June 1989 (RWQCB 1990).

Algae and macrophyte respiration are believed largely responsible for the diurnal fluctuations in dissolved oxygen concentrations. A 1973 diurnal water quality study indicated fall dissolved oxygen fluctuations of 5.5 mg/L at the Shasta River above Yreka Creek. Spring and summer diurnal dissolved oxygen fluctuations range from 2.2 to 6.6 mg/L in the Shasta River.

Diurnal fluctuations may expose fish to low dissolved oxygen concentration for several hours. The physiological effects on fish of large daily fluctuations in dissolved oxygen concentrations in the Shasta River has not been examined.

Electrical conductance increases with downstream movement. EC generally range from 400 to 700 μmhos/cm with seasonal highs from July through September and low levels from November through March. Conductivity increases substantially below the Montague-Grenada Road, possibly due to agricultural return flows. Electrical conductivity values generally found in Shasta Valley surface waters are suitable for all current beneficial uses.

Alkalinities of the Shasta River generally range from 150 to 400 mg/L, and are generally suitable for all beneficial uses.

The RWQCB has designated a range (7.0 to 8.5) of acceptable pH values for Shasta Valley surface water (RWQCB, 1989). Shasta Valley surface waters are infrequently more basic during times of large diurnal dissolved oxygen and temperature fluctuations. pH fluctuates diurnally, increasing during the evening due to photosynthetic removal of CO_2. Five of seven Shasta River stations collected on May 1, 1990 contained pH values in excess of 8.5.

Mineral Quality

Shasta Valley surface waters are generally of excellent mineral quality, and are described as magnesium-bicarbonate in the upper watershed and calcium-magnesium-bicarbonate in the lower portion of the watershed. The upper stream tributaries to the Shasta River contain relatively low mineral content and have low total dissolved solid content. TDS levels in the Shasta River increase in a downstream direction from 0.49 mg/L in the upper reaches. Median TDS levels are reported as 6 mg/L in the Shasta River (DWR 1986). Lower tributaries contain greater TDS levels than the Shasta River.

Chloride concentrations ranged from 10 to 45 mg/L in the Shasta River, and increased with downstream movement. Irrigation return flows seasonally increase summer and fall chloride levels.

RWQCB objectives call for boron levels less than 1.0 mg/L in the Shasta River and less than 0.5 mg/L in its tributaries. Shasta River boron concentrations average 0.5 mg/L and range as high as 1.1 mg/L. Oregon Slough, Little Shasta River, Willow Creek and Julian Creek all contain elevated boron levels and contribute poor mineral quality water to the Shasta River. Both Oregon Slough and the Little Shasta River flow from springs in the Table Rock area which are high in boron. Both streams provide a major portion of the flow in the lower Shasta River and are believed to be the source of the elevated summer and fall boron levels in the Shasta River. Willow and Julian Creeks receive irrigation return flows, the sources of which are highly mineralized (including high boron) waters of deep origin. WDIS data indicate boron levels from the Little Shasta River potentially harmful to some crop species. Sensitive crop species are affected by boron levels of as little as 0.75 mg/L. Maximum boron concentrations recorded in the Little Shasta River exceed 2.3 mg/L. Approximately 5.8 percent, 7.6 percent, and 20.0 percent of the samples collected at the Shasta River near Yreka, Shasta River above Yreka Creek, and Oregon Slough, respectively, exceed 0.75 mg/L of boron.

Nutrient Quality

The RWQCB has not set nutrient objectives for the Shasta River. The limited nutrient data reviewed indicate all nutrient levels are below nuisance levels or drinking water standards.

Some pre-1971 municipal waste discharges occurred into some Shasta Valley streams (Piemme, Neill and Bryan 1973). These winter discharges were believed to contain elevated phosphates and nitrate levels.

Dissolved orthophosphate levels in the Shasta River have a mean value of 0.15 mg/L. Total phosphorus and dissolved nitrate levels up to 2.1 mg/L and 1.2 mg/L, respectively, have been recorded from Yreka Creek above the Shasta River. Inadequate nutrient data is available to identify the nutrients responsible for excessive algae and macrophyte growth in the Shasta River or to design methodologies for their control.

Minor Element Quality

A very limited amount of minor element data were available for review. Analyses of antimony (Sb), barium (Ba), beryllium (Be), cobalt (Co), molybodenum (Mo), thallium (Tl) and vanadium (V) concentrations in Shasta Valley surface waters have been conducted only once. None of these minor elements were present in concentrations above minimum detection limits.

Copper (Cu) concentrations in excess of 0.02 mg/L have been recorded from the Shasta River near Montague, Big Springs, and the Shasta River near Big Springs. The toxicity of copper on freshwater aquatic life varies significantly between species, but also with temperature, hardness, turbidity, carbon dioxide content, and chemical composition. Copper can also act synergistically in the presence of zinc, cadmium, or mercury (McKee and Wolfe 1971). No RWQCB objectives for Shasta Valley surface water copper concentrations have been set. McKee and Wolf (1973) recommend 0.02 mg/L of copper as the threshold concentration to maintain freshwater aquatic life. More recent EPA recommendations indicate levels above 0.018 ppm can cause acute problems to fresh water organisms. The maximum copper concentration observed in Shasta Valley surface waters was 0.05 mg/L.

Manganese concentrations above the EPA drinking water standard (0.05 mg/L) have been recorded at the Shasta River near Big Springs, Shasta River above Yreka Creek, and Shasta River near Yreka monitoring stations. The maximum manganese concentration encountered was 0.54 mg/L. The drinking water standard was set based on aesthetic and economic considerations rather than human physiological hazard. Manganese concentrations above 0.05 mg/L can impart an undesirable taste, cause deposits on food during cooking, and stain laundry or plumbing fixtures. Manganese concentrations of 0.5 mg/L have been reported harmful to various plants when used for irrigation (Morris and Pierre 1949).

Iron (Fe) concentrations exceeded the EPA drinking water standard of 0.3 mg/L. Iron concentrations above 0.3 mg/L were present at the Shasta River near Yreka and Shasta River below Little Shasta River monitoring stations. Iron concentrations in the Shasta River ranged as high as 13.0 mg/L. Like manganese, the EPA criteria for iron is based on factors other than human physiologic hazard.

A single selenium (Se) concentration at the minimum detection level of 0.01 mg/L was recorded at the Shasta River above Yreka monitoring station. This level is not known to be hazardous to aquatic life or human health.

Inadequate minor element data exists to determine sources or problem areas. Some streams have never been sampled and most have not been sampled for 25 to 30 years.

Coliform Bacteria

The RWQCB standard for fecal coliform in Shasta Valley surface water states that fecal coliform shall not exceed a median value of 50 colonies per 100 ml based on at least five samples and that no more than 10 percent of the samples collected during a 30-day period shall exceed 400 colonies per 100 ml.

Fecal coliform was sampled from three Shasta River stations on September 28, 1988. Fecal coliform levels ranged from 240 to 1600 colonies per 100 ml. The highest fecal coliform level observed was at the Highway 3 bridge, with both upstream and downstream stations at lower levels. These very limited data suggest human health risk from water contact recreation and domestic use of the Shasta River.

Pesticides

Pesticide concentrations had been determined for six surface water quality stations in the Shasta Valley between 1973 and 1986. The stations and years sampled are: Shasta River near Yreka (1973, 1973, 1974, 1975, 1976, 1986), Shasta River above Yreka Creek (1973), Yreka Creek above the Shasta River (1973), Shasta River at the Little Shasta River (1973), Little Shasta River near Ball Mountain Road (1973), and Shasta River below Dwinnel Reservoir (1973). Two scans (chlorinated hydrocarbons and organic phosphorus) were conducted on all dates. Chlorinated hydrocarbons were identified (0.0001 mg/L) at the Shasta River near Yreka. Lesser amounts (0.00004 to 0.000075 mg/L) of chlorinated hydrocarbons were present at all other stations except Little Shasta River near Ball Mountain Road. Concentrations of Dieldrin (0.000015 mg/L) were present at Shasta River below Dwinnell Reservoir during May 1973. Methyl parathion concentrations (0.000050 mg/L) were detected at the Shasta River near Yreka during 1976. Atrazine concentrations (0.0004) were detected at the same station during 1986. These pesticide levels were not considered significant.

Limnology

Lake Shastina, a 50,000 ac-ft water storage reservoir, is the only large reservoir within the Shasta Valley. Limited long-term limnological data were reviewed from Lake Shastina. Big Springs Lake and several small closed basin lakes located in the south-central portion of the Shasta Valley have been sampled minimally.

Surface water quality sampling of the small closed basin lakes revealed alkali conditions with pH values greater than 9.0. Electrical conductivity ranged to a maximum of 12,420 μmhos/cm. Both sodium and chloride concentrations exceeded 2,700 mg/L. Total dissolved solids in excess of 7,400 mg/L have been recorded. Elevated boron and aluminum levels were also present. These lakes concentrate mineral salts through evaporation. Waters of these lakes are unsuitable for most beneficial uses.

Surface water quality sampling of Big Springs Lake has occurred only on a very limited basis. Extremely high dissolved CO_2 levels (68 mg/L) should preclude fish use of the lake. Dissolved CO_2 levels in excess of 12 mg/L are believed to be lethal to fish. Approximately one mile below the lake, dissolved CO_2 concentrations drop to less than 10 mg/L in Big Springs Creek.

Copper concentrations in excess of 0.02 mg/L have been measured in Big Springs Lake. This level of copper is considered above the threshold level for protection of aquatic life. Excessive growth of algae in Big Springs Lake is frequently cited as a localized water quality problem within the Shasta Valley (DWR 1959, DWR 1960).

Lake Shastina has been subject to sporadic limnological sampling since 1967. The USGS conducted the most intensive sampling effort during 1972. Lake Shastina waters are characterized as magnesium-bicarbonate in nature. Monitoring results indicate thermal stratification from June through September. Supersaturated dissolved oxygen concentrations in the epilimnion are common during thermal stratification. During August 1989, surface dissolved oxygen concentrations were 6.6 mg/L and decreased rapidly with increasing depth. Anoxic conditions frequently exist in the hypolimnion during stratification (WDIS-1989). Anoxic conditions allow nutrients in the bottom sediments to be released. Elevated levels of orthophosphates, total phosphorus, dissolved nitrate and total nitrogen were detected in the hypolimnion. The USGS (1974) reported vertical stratification of carbon dioxide, carbonate, bicarbonate, pH, nitrogen, and phosphorus during periods of thermal stratification. All mineral, nutrient and minor element data reviewed were within Regional Water Quality Control Board standards.

Excessive algal growth in Lake Shastina has been reported (DWR 1959, 1960). Over 33 algal species have been identified in the lake with green algae and diatoms being the dominant groups. Green algae populations are reported to be relatively stable throughout the year with an average density of one million cells per liter. Diatom populations fluctuate throughout the year and reach significant concentration during blooms of Fragillaria crotonemsis. Surface nutrient samples collected on August 30, 1989 indicated high (0.79 to 0.90 mg/L) total organic nitrogen content. The same samples indicated little or no dissolved nitrogen was present, which indicates that all the available nitrogen was tied up in algal biomass with little available for additional growth. High dissolved orthophosphate levels were also present. These conditions favor blooms of nitrogen fixing blue-green algal species. Spring blooms of blue-green algae have been recorded in concentrations of five million cells per liter. These levels are capable of producing taste and odor problems in drinking water.

Benthic Macroinvertebrates

Benthic macroinvertebrate data were collected during 1973, 1981, 1982 and 1983 from nine Shasta Valley locations. Community diversity and ecological relationships of benthic populations were analyzed for each of the following stations.

Shasta River below Lake Shastina This station exhibited relatively moderate species richness and moderate to low diversities. Diversities were low due to very low equitabilities produced by single species numerical dominance. Taxa which require higher levels of dissolved oxygen were notably absent.

Shasta River near Big Springs High species richness and variable (high to low) diversities were recorded at this station. Molluscs and amphipods were present with greater species richness and diversity than found in the upstream station. This increase in these two groups was suspected to be related to substantial increases in electrical conductivity and alkalinity.

Shasta River near Grenada High species richness and moderate to moderately high diversities were present at this station. The presence of abundant periphyton provided habitat for several taxa not found at other stations. Stream temperatures may approach levels above those suitable for mayfly and stonefly species.

Shasta River above or below Little Shasta River This station exhibited high species richness. Diversities and equitabilities were low during spring sampling and moderate to moderately high during the summer. Taxa adapted to periphyton growth and silty conditions were relatively abundant.

Shasta River above Yreka Creek Community diversity analysis at this station indicated some form of adverse impact to the community between the summer 1981 and spring 1982 sampling periods. Drastic reductions in species richness, diversity and equitability were recorded. Further sampling indicated a recovery to a healthy benthic community during 1983.

During low flow conditions, silt tolerant taxa were extremely abundant while silt intolerant taxa were found to be proportionately lower. Several taxa were present which were not found at other stations. Stream temperatures were thought to approach levels above those suitable for mayfly and stonefly species.

Shasta River near Mouth The community composition at this site differed substantially from those collected upstream. Filter feeders were the dominant group. Both molluscs and amphipods which exhibited reduced populations, can be adversely affected by high dissolved oxygen fluctuations. Other indicator species of inadequate dissolved oxygen levels did not, however, exhibit reduced populations from those found upstream. Marginal substrate (cemented gravels) were also cited as a factor in the community differences.

Yreka Creek above Shasta River Species richness and community abundance followed typical seasonal patterns with lower diversities and species richness during spring sampling. The dominant taxa during nearly all sampling was Tanytarsus, which is strongly associated with coarse silt. The presence of exposed bedrock at this station also produced large populations of taxa which require clean substrate for attachment. Diversities and abundances of mayflies, crustaceans, and gastropods were substantially lower than in the Shasta River.

SUMMARY

This literature review has identified water quality conditions which impact the beneficial uses of waters within the Shasta Valley. Water quality conditions which could potentially impair beneficial uses are summarized below. Situations where current data is inadequate to identify impairment of beneficial uses are also identified.

Domestic uses of Shasta Valley ground water are impaired in a limited number of sites by elevated sodium, nitrate, manganese, iron and pentachlorophenol. No data have been collected on ground water concentrations of nutrients, coliforms or pesticides. High ground water levels, increased rural subdivision (dependent upon septic systems), and intensive livestock grazing can potentially lead to increased concentrations of nitrate and coliforms in ground water. Pesticide studies in other areas have shown pesticide movement into ground water is generally associated with coarse alluvial soils, areas where large amounts of water are applied to soils above natural precipitation, unconfined aquifers with depth to the water table less than 30 feet, extensive or concentrated pesticide use occurring over many years, and use of highly persistent or mobile pesticide (SWRCB 1984). Many of the criteria could apply to portions of the Shasta Valley.

Shasta Valley ground water is generally of good quality for irrigation purposes. However, individual wells contain levels of electrical conductivity, TDS, sodium, sulfate, chloride, copper, and boron which could impair their use as irrigation water.

Runoff from ground water used in irrigation reach surface water and can influence aquatic life. The influence of irrigation return flows from ground water sources on aquatic life have not been examined.

Current ground water quality monitoring efforts are inadequate for several reasons including spotty sampling (i.e. few areas and fewer aquifers are sampled); inadequate minor element analysis; absence of coliform, pesticide and nutrient data; and insufficient number of sampling sites and sampling repetitions. The historic sampling effort is inadequate to identify the extent of known ground water quality problems or to detect all the potential problems.

Domestic use of surface waters is potentially impaired due to the presence of high manganese, iron, and coliform concentrations.

Irrigation uses of Shasta Valley surface water are impacted by seasonally high boron concentration above RWQCB standards.

Aquatic life is adversely affected by seasonally high temperatures. Temperature directly impacts cold freshwater habitat. Summer and fall temperatures are at hazardous to lethal levels and undoubtably limit seasonal cold freshwater species habitat use in the lower Shasta River.

High seasonal temperatures may also impact fish migration and spawning habitat beneficial uses in Shasta Valley surface waters. Fall surface water temperatures are at levels which could delay adult migration, result in reduced adult survival and vigor, and reduce the viability of eggs.

Agricultural return flows increase temperature and total dissolved solid levels which serve to reduce the dissolved oxygen carrying capacity. Low dissolved oxygen levels can increase the toxicity of high dissolved CO_2 and copper levels found within the Shasta River system. Low dissolved oxygen levels alone can be lethal to some forms of aquatic life. Although dissolved oxygen levels below 3.0 mg/L occur diurnally throughout the Shasta River system during the warmer seasons, short-term exposure to these levels is not known to be directly lethal to fish.

The Shasta River dissolved oxygen levels are frequently below the RWQCB standard of 7.0 mg/L. Algal and macrophytic respiration are believed to be responsible for the high diurnal dissolved oxygen fluctuations.

Nutrient data are currently inadequate to develop methodologies for control of algae and macrophytes to below nuisance levels.

Surface water quality information on minor element (metal) concentrations is extremely limited. Copper concentration at levels hazardous to aquatic life have been recorded from Big Springs and the Shasta River.

Limited pesticide analysis of surface waters reveal no significant accumulations of pesticides.

Several small closed basin lakes are present which accumulate mineral salts through evaporation. These lakes are unsuitable for almost all beneficial uses. Big Springs Lake contains high dissolved CO_2 levels (5.6 times the level known to be lethal to fish) and copper concentration above the EPA criteria for protection of aquatic life. Lake Shastina is subject to blooms of blue-green algae which have produced taste and odor problems.

Benthic macroinvertebrate populations are generally diverse. At specific stations, low dissolved oxygen levels and high temperatures are suspected of eliminating certain taxa. Benthic populations are largely controlled by bottom substrate. Those stations where the substrate consisted of excessive periphyton, silt or cemented gravels had taxa representative of those conditions.

The current surface water quality monitoring network consists of monthly sampling of three surface water stations on the Shasta River. These monthly sampling efforts are restricted to the collection of physical water quality characteristics. Approximately once per year mineral quality is accessed.

Nutrient and minor element data are examined much less frequently. This intensity of sampling is inadequate to determine current conditions, trends, or monitor the effectiveness of water quality improvement programs. Additional stations on the Shasta River and the major tributaries with increased sampling of nutrients and minor elements are necessary.

Almost all the extensive temperature records collected within the Shasta Valley are the result of grab sampling techniques. Grab samples give an accurate reading at a single point in space and time. No information is available to determine effects of diurnal temperature fluctuations on aquatic life, or factors contributing to those fluctuations.

The effects of high diurnal dissolved oxygen fluctuations on aquatic life are largely unknown. Some benthic macroinvertebrate taxa dependent upon high dissolved oxygen concentrations are absent from portions of the Shasta River. Dissolved oxygen levels are frequently below minimum RWQCB standards. The cause of these high dissolved oxygen fluctuations are assumed to be macrophyte and algae production and respiration. Sources of nutrients responsible for macrophyte and algae growth have not been identified.

Information on coliform levels within the Shasta Valley are inadequate but suggests a significant health hazard to water contact recreation and domestic use. Sources of coliform contamination have not been identfied.

Pesticide contamination of surface water is not currently considered a problem. Bioaccumulation of some pesticides is possible, but no data are available to assess this potential problem.

Elevated dissolved CO_2 levels in the Big Springs system produces conditions unsuitable for some forms of aquatic life.

Blue-green algae are occasionally present in Lake Shastina at nuisance levels. The role of nutrients in contributing to excessive algal growth has not been investigated.

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1. **California Department of Fish and Game. 1989. Shasta River Monitoring Results - Unpublished Data.**

These data show the results of analyses of physical water quality parameters collected during 1985, 1986, 1987, and 1988 from seven surface water quality monitoring stations on the Shasta River. It is unclear when some of the samples were collected. However, stream temperatures between 70°F and 80°F were common. Dissolved oxygen levels below 5.0 mg/L were present at two stations (Shasta River at the Montague-Grenada Road, Shasta River at Highway 3). All pH values ranged from 7.0 to 8.5.

2. **California Department of Water Resources. 1951. Investigation of effects of high ground water table on disposal of sewage by septic tanks near Montague, Siskiyou County.**

This study examines the effect of a high ground water table and septic systems on ground water quality in Montague. The study found that most septic systems were located largely or entirely below the ground water level. No bacteriological samples were collected. Chemical analysis of ground water from seven wells within Montague revealed two wells with nitrate concentrations above 45 mg/L. Nitrate concentrations in one domestic well ranged to 72 mg/L.

3. **California Department of Water Resources. 1959. Shasta Valley Water Quality Investigation.**

This report identified surface and ground water quality within the Shasta Valley prior to 1959. The report also predicted changes in water quality from proposed water resource development projects within the basin.

Surface water quality was generally rated as good to excellent for most uses. Upper stream tributaries to the Shasta River were of excellent quality. Lower tributary streams generally contained greater mineral concentrations than the Shasta River which displayed increased total dissolved solid (TDS) content in the lower reaches. Streams in the lower Shasta Valley contained boron concentrations unsuitable for long term irrigation of sensitive crop species. Numerous small lakes were identified with levels of TDS and boron which impaired their use as irrigation waters.

Ground water quality was also considered excellent for most uses. Three areas, including along Oregon Slough and Little Shasta River, the vicinity of the proposed Montague Reservoir site, the area between Grenada and Big Springs, were identified as containing ground water unsuitable for irrigation of some crops due to high TDS and boron concentrations.

Other localized water quality problems identified included disposal of municipal waste, irrigation return flows, excess concentrations of CO_2 in Big Springs Lake, adverse salt balance in small closed hydrologic basins, and algal growth in reservoirs (Lake Shastina and Big Springs Lake).

4. **California Department of Water Resources. 1960. Northeast Counties Investigation, Bulletin No. 58.**

This report contained a brief overview of water quality and water quality problems within the Shasta Valley. Excessive concentrations of boron, magnesium, fluoride, sulfate, and nitrates were cited as localized ground water quality problems in Shasta Valley. Contamination of ground water from septic system and surface water from municipal sewage treatment facilities percolation beds were identified. The Little Shasta area of Shasta Valley and the Willow Creek drainage contained high concentrations of boron, TDS, and percent sodium. The levels of these constituents in the ground water of these two areas preclude their use for irrigation for all but the most salt-tolerant crops.

5. **California Department of Water Resources. 1964. Shasta Valley Investigation, Bulletin No. 87.**

This study reported uniform surface water quality throughout the Shasta Valley. Water in the upper watershed contained relatively low mineral content, low total dissolved solids levels, and was magnesium-bicarbonate in character. Mineral content and TDS gradually increased downstream. Waters of the lower watershed were classified as calcium-magnesium bicarbonate in nature. Oregon Slough, Little Shasta River, Willow Creek, and Julian Creek all contained elevated boron levels and were of inferior quality to the Shasta River. Oregon Slough and the Little Shasta River, which were high in boron, flow from springs in the Table Rock area. These springs constitute a major portion of the flow into the Shasta River during low flow conditions and were responsible for the high boron content of the Shasta River under these conditions. Both Willow Creek and Julian Creek received irrigation return flows from an area of highly mineralized ground water of deep origin.

A number of small lakes with no drainage occurred in the south central portion of the valley. Mineral concentration due to evaporation yields waters high in boron and TDS, which are unsuitable for agriculture.

Ground water is described as a calcium-magnesium bicarbonate type with TDS values ranging from 91 to 4,870 mg/L. Wells yielding poorer water quality were found at Oregon Slough and Little Shasta River, near Montague, and between Grenada and Big Springs.

The principal water quality problems in the Shasta Valley were identified as disposal of municipal waste, irrigation return flows, excess concentrations of CO_2, adverse salt balance in small closed basins, and algal growth. The major flow in the Shasta River during the irrigation season was irrigation return waters of good to excellent quality for irrigation. Big Springs Lake contained CO_2 concentrations in excess of 68 mg/L. Fish cannot live throughout the year in waters containing over 12 mg/L CO_2. Approximately 1 mile below the Big Springs Lake outfall, CO_2 concentrations drop to 10 mg/L. Small amounts of algae were present in Big Springs Lake and Lake Shastina.

Ground water problems were linked to natural causes. Highly mineralized magmatic waters, such as those of Table Rock Springs, produced high boron, chloride and sodium levels.

6. **California Department of Water Resources. 1973. Shasta Valley Diel Data.**

These unpublished data contain diurnal surface water quality information collected from six stations during 1971, 1972 and 1973 within the Shasta Valley. No data analysis are presented.

Spring (May and June) diurnal temperature fluctuations ranged from 51.8°F at the Shasta River near Yreka to 40.1°F at the Shasta River above Little Shasta River. Fall (September) diurnal temperature fluctuations ranged from 48.7°F at the Shasta River near Yreka to 37.5°F at Yreka Creek above the Shasta River. June temperatures ranged to a maximum of 78°F with maximum values at all stations exceeding 70°F. September temperatures ranged to a maximum value of 73.4°F.

Spring diurnal dissolved oxygen fluctuations ranged from 0.7 mg/L at the Shasta River below Shastina to 5.5 mg/L at the Shasta River about Yreka Creek. Fall diurnal dissolved oxygen fluctuations ranged from 1.5 mg/L at the Shasta River near Yreka to 6.6 mg/L at the Shasta River above Yreka Creek. Two dissolved oxygen values less than 5.0 mg/L were recorded at the Shasta River above Yreka Creek station between 2200 and 2400 PST during May 1973. A single dissolved oxygen value less than 5.0 mg/L was recorded at the Shasta River below Lake Shastina in September 1973.

7. **California Department of Water Resources. 1973. Unpublished Benthic Macroinvertebrate Data.**

Thirteen benthic macroinvertebrate samples were collected from nine stations within the Shasta Valley during 1973. The samples were sorted, identified and tabulated. Total density of each benthic macroinvertebrate species was determined. Community diversity was not calculated.

The dominant species present in the Shasta River included Tricorythodes fallax, Baetis sp., Hyalella sp., Hydropsyche sp., Pleuroceridae sp., Hyalella azteca, and Lymnaea sp. The dominant species in the Little Shasta River included Simulium sp. and Hydropsyche sp.. Oregon Slough had very few species and was dominated by Plesiopora sp.(an annelid). Simuliam sp. and Tendipedidae spp. were dominant in Yreka Creek, during September and May samples, respectively.

8. **California Department of Water Resources. 1976. Siskiyou County and Land Uses and Water Demands.**

This report contains a very brief description of Shasta Valley ground water quality. Ground waters were characterized as bicarbonate without a predominant cation. Ground waters are considered moderately hard (100 to 200 mg/L as $CaCO_3$). Total dissolved solids concentrations were described as ranging from 300 to 600 mg/L. Generally, pH ranged from 7.0 to 8.5. Percent sodium values were generally less than 30 percent. Several wells were identified which contained iron and arsenic values of 0.3 mg/L and 0.01 mg/L, respectively. These iron and arsenic values were considered marginal for drinking water.

9. **California Department of Water Resources. 1986. Shasta/Klamath River Water Quality Study.**

This report presents all the surface water quality data collected by DWR prior to 1984. A brief summary of findings was also included.

Dissolved oxygen diurnal fluctuations of 5.0 mg/L were reported in the Shasta River. Stream temperature diurnal fluctuations of 39.5° to 46.4°F during summer months and 2°to 4°C during February were present. Maximum summer temperatures of 71.6° to 82.4°F occurred frequently on the Shasta River. Suspended solids ranged from 0 to 49 mg/L with a medium value of 6 mg/L. Seasonal variations in electrical conductivity (EC) were observed. EC values ranged from 400 to 700 umhos/cm with higher values from July through September and lower values from November through March.

Chloride concentrations ranged from 10 to 45 mg/L. Irrigation return flows were identified as the main source of increased summer chloride levels. Boron concentrations averaged 0.5 mg/L and ranged as high as 1.1 mg/L. Alkalinities ranged from 150 to 400 mg/L. Orthophosphate concentrations varied widely with a median value of 0.15 mg/L.

Benthic macroinvertebrate samples were collected from seven stations within the Shasta Valley during spring and summer sampling in 1981, 1982 and 1983.

10. **California Department of Water Resources. 1990. Lake Shastina Limnology Data File. Unpublished data.**

These files contain raw limnological data collected sporadically at Lake Shastina since 1967. Recent data (1986, 1989, and 1990) contain full mineral, nutrient, and minor element analysis of surface and bottom samples. Samples collected in 1967, 1978, and 1985 contain only surface nutrient analyses. Sampling on most dates also included collection of physical water quality parameter profile data.

Mineral and minor element analysis reveal suitable water quality for most beneficial uses. Dissolved nitrate concentrations (3.1 mg/L) approaching the RWQCB's Interim Water Quality Control Plan of 4.0 mg/L were present in a bottom sample collected on August 30, 1989.

Very low dissolved oxygen concentrations were observed in profiles collected on August 30, 1989. Dissolved oxygen concentrations of 6.6 mg/L, 5.0 mg/L, 4.0 mg/L, and 0.2 mg/L were recorded at the surface, 1 m, 3 m, and bottom, respectively. Samples collected above 8 m had pH values of 9.0 or greater. On May 17, 1989, dissolved oxygen levels were below 5.0 mg/L at depths below 8 m.

11. **California Department of Water Resources. 1990. Water Data Information System. Ground water. Unpublished data.**

The Department has collected ground water quality information within the Shasta Valley since the mid-1950s. Approximately 106 wells have been sampled within the valley. Only 18 wells are currently being sampled. Over 500 mineral samples have been collected. Few metal analyses (20 wells) and no nutrient data have been collected.

Ground water temperatures are of questionable reliability due to holding tanks and other sampling problems. Approximately forty-nine percent of the temperature measurements exceeded 60°F and eight percent were 70°F or greater. All pH values were within acceptable levels for most beneficial uses. Electrical conductivity values were generally excellent. However, two wells contained EC values over 2,000 μmhos/cm and one well had an EC of 7,400 μmhos/cm.

Calcium, magnesium, sodium, and potassium concentrations were generally below 50 mg/L. Three wells contained sodium concentrations ranging from 200 mg/L to 1,740 mg/L. Alkalinity values were generally between 200 and 400 mg/L, but ranged as high as 1,210 mg/L. Sulfate, chloride, and nitrate levels were generally at levels suitable for all uses. Only one well contained sulfate concentrations in excess of 200 mg/L. Four wells had chloride levels over 200 mg/L and one sample contained 860 mg/L. Seven wells contained nitrate levels in excess of the EPA drinking water standard of 45 mg/L. The maximum nitrate level recorded was 81 mg/L. Total dissolved solid (TDS) content varied widely from well to well. Four wells had TDS values ranging from 700 to 4,862 mg/L. Approximately eight percent of the wells contained boron levels which could injure sensitive crop species if used for irrigation. Boron levels in these wells ranged from 0.75 to 14.0 mg/L.

Aluminum, arsenic, chromium, cadmium, lead, mercury, selenium, and silver were found at levels suitable for all beneficial uses. Manganese was found in one well at levels (0.8 mg/L) which could impair use for laundry purposes. Likewise, iron was also present in two wells at levels unsuitable for laundry purposes. Copper concentrations up to 0.39 mg/L, which are potentially harmful to aquatic life, were present in one well. Zinc in excess of 0.1 mg/L can also be harmful to aquatic life and was present in four wells.

12. **California Department of Water Resources. 1990. Water Data Information System. Surface Water. Unpublished data.**

Surface water quality monitoring has been conducted within the Shasta Valley since the mid-1950s. Approximately 48 surface water quality monitoring stations have been sampled within the Shasta Valley. The majority of these stations have not been sampled since the 1950s. DWR currently samples only three stations (monthly) on the Shasta River. Monthly grab samples collected between 7 a.m. and 5 p.m. do not discern diurnal water quality fluctuations and can miss major storm events.

WDIS records generally contain dissolved oxygen, electrical conductivity, pH, and temperature data at each sampling. Mineral data are less common and nutrient and minor element data are extremely limited. A single pesticide scan was conducted on a few stations during 1973.

WDIS grab samples indicate stream temperatures in excess of 60°F are common throughout the Shasta Valley (Table 2). Lower Shasta River stations infrequently exceed 80°F during summer sampling. Stream temperature in the Shasta River below Lake Shastina exceeded 60°F in over half the samples collected.

Table 2. Shasta Valley Surface Water Temperatures

Station	%>60° F	%>70° F	%>80° F
Shasta River near Yreka	41.4	17.8	2.5
Shasta River above Yreka Creek	46.1	21.5	1.2
Yreka Creek above Shasta River	56.6	9.4	-
Oregon Slough at Montague	60.0	20.0	-
Shasta River near Grenada	38.7	6.9	-
Shasta River near Big Springs	46.1	10.2	-
Shasta River below Lake Shastina	51.1	12.7	-
Shasta River below Little Shasta River	49.9	29.1	-

pH values in excess of 8.5 (indicating alkaline conditions) occurred in the lower Shasta River sporadically during low-flow conditions. pH values in excess of 8.5 occurred at the Shasta River near Yreka in 8.2 percent of the samples and at the Shasta River above Yreka Creek in 2.4 percent of the samples.

Boron concentrations exceeded 0.75 mg/L (level known to cause damage to sensitive crop species in long-term irrigation waters) in all samples collected on the Little Shasta River with a maximum value of 2.4 mg/L. The Shasta River near Yreka, Shasta River above Yreka Creek, and Oregon Slough contained excessive concentrations of boron in 5.8 percent, 7.6 percent, and 20.0 percent of the samples collected, respectively.

The Shasta River below Lake Shastina was the only WDIS station which showed depressed dissolved oxygen concentrations (<5.0 mg/L). Most of the flow at this station may be the result of seepage or underground flow. Approximately 7 percent of the samples collected at this station had dissolved oxygen concentrations between 4.7 and 5.0 mg/L.

Yreka Creek above the Shasta River contained elevated total phosphorus levels (2.1 mg/L) and dissolved nitrate (1.2 mg/L). Generally, however, nutrient levels were within Regional Water Quality Control Board guidelines.

Copper concentrations in excess of 0.02 mg/L were present at Big Springs Reservoir, Shasta River near Montague, Big Springs, and Shasta River near Big Springs stations. The maximum concentration of copper detected was 0.05 mg/L.

Manganese concentrations above the EPA drinking water standard of 0.05 mg/L were present in Lake Shastina, Shasta River near Big Springs, Shasta River above Yreka Creek, and Shasta River near Yreka stations. Manganese concentrations as high as 0.54 mg/L were present.

Iron concentrations also exceeded EPA drinking water standards (0.3 mg/L). Shasta River near Yreka and Shasta River below Little Shasta River had iron concentrations ranging from 2.3 to 13.0 mg/L.

A selenium value of 0.01 mg/L was detected at the Shasta River above Yreka Creek. This is the only selenium value above detection limits within the Shasta Valley.

Two small closed basin lakes located near Grenada contained numerous water quality problems including pH greater than 9.0, electrical conductivity levels to 12,420 μmhos/cm, sodium and chloride concentrations in excess of 2,700 mg/L, total dissolved solid levels of 7,484 mg/L, and aluminum concentrations as high as 0.9 mg/L.

13. **California Regional Water Quality Control Board, North Coast region. 1971. Interim Water Quality Control Plan for the Klamath River Basin.**

This regulatory document does not present any water quality data. The plan identifies the beneficial uses of water and waste discharges within the Shasta Valley. Waste water management goals and land and water use management guidelines are presented. The beneficial uses of Shasta Valley waters include municipal, domestic, agricultural, and industrial supplies; scientific study; aesthetic enjoyment; freshwater fish and wildlife habitat; ground water recharge, fish spawning and migration; and water-contact and nonwater-contact recreation.

Water quality objectives were established for the Shasta River, including electrical conductivity (<750 μmhos/cm) total dissolved solids (<0.52 mg/L), dissolved oxygen (>8.0 mg/L), and pH (<8.5 but >6.5).

Four municipal waste water treatment facilities (City of Yreka, City of Weed, City of Montague, and Shastina Sanitary District) construction projects were identified and uses of reclaimed water were specified.

14. **California Regional Water Quality Control Board, North Coast Region. 1989. Water Quality Control Plan for the North Coast Region.**

This regulatory document updated the water quality objectives identified within the 1971 Regional Water Quality Control Plan for the North Coastal Region.

Current beneficial uses of water in the Shasta Valley include municipal and domestic supply, agricultural supply, groundwater recharge, freshwater replenishment, water contact recreation, non-contact water recreation, warm freshwater habitat, cold freshwater habitat, wildlife habitat, freshwater fish migration and spawning habitat.

The water quality control plan prohibited color, taste, odor, floating material, suspended material, settleable material, oil, grease, biostimulatory substances, and sediments at levels which adversely effect beneficial uses or are a nuisance. Turbidity levels may not exceed 20 percent above background levels. Minimum dissolved oxygen concentrations allowed are 7.0 mg/L except during critical spawning and egg development periods when dissolved oxygen concentration must remain above 9.0 mg/L. Shasta Valley waters may not exceed a median fecal coliform concentration of 50 colonies per 100 ml (5 samples per 30 days). No more than 10 percent of the fecal coliform samples within a 30 day period may exceed 400 colonies per 100 ml. No elevated temperature waste discharges are allowed into cold interstate waters. The Klamath River is classified as cold interstate waters. Toxic substances may not occur at levels which produce detrimental physiological responses in human, plant, animal, or aquatic life. No bioaccumulation of pesticides or concentrations which effect beneficial uses may occur. Shasta Valley water quality objectives for physical water quality parameters and chemical composition are presented in Table 3. Additionally, this plan mandates that ground water used for agricultural supply shall not contain concentrations of chemical constituents in amounts that adversely effect such beneficial uses.

Water Quality Objectives for the Shasta Valley

Table 3

	Source			
Parameter	Shasta River	Other Streams	Lake Shastina	Ground Water
Electrical conductivity (micro μmohs/cm)	800	700	300	800
dissolved oxygen (mg/L)1/	7.0	7.0	6.0	---
pH2/	7.0-8.5	7.0-8.5	7.0-8.5	7.0-8.5
Hardness (mg/L)	220	200	120	180
Boron (mg/L)	1.0	0.5	0.4	1.0
Fluoride (mg/L)3/	1.4-2.4	1.4-2.4	1.4-2.4	1.4-2.4
Arsenic (mg/L)	0.05	0.05	0.05	0.05
Barium (mg/L)	1.0	1.0	1.0	1.0
Cadmium (mg/L)	0.01	0.01	0.01	0.01
Chromium (mg/L)	0.05	0.05	0.05	0.05
Lead (mg/L)	0.05	0.05	0.05	0.05
Mercury (mg/L)	0.002	0.002	0.002	0.002
Nitrate (mg/L)	45	45	45	45
Selenium (mg/L)	0.01	0.01	0.01	0.01
Silver (mg/L)	0.05	0.05	0.05	0.05
Endrin (mg/L)	0.002	0.002	0.002	0.002
Lindane (mg/L)	0.004	0.004	0.004	0.004
Methoxychlor (mg/L)	0.1	0.1	0.1	0.1
Toxaphene (mg/L)	0.005	0.005	0.005	0.005
2,4 D (mg/L)	0.1	0.1	0.1	0.1
2,4,5 TR Silver (mg/L)	0.01	0.01	0.01	0.01

1/ Minimum concentration
2/ Range of acceptable values
3/ Temperature dependent

15. **California Regional Water Quality Control Board, North Coast Region. 1990. Cease and Desist Order No. 90-31 for the Hi-Ridge Lumber Company, Siskiyou County.**

This cease and desist order prohibits further discharge of wood treatment chemicals or stain control fungicides to surface or ground water. Until 1987, chlorophenols were used as an ingredient in a liquid fungicide solution at the Hi-Ridge Lumber Mill. Subsequent investigation at the site revealed chlorophenol concentrations in excess of 300 micrograms per liter in ground water and 66,000 micrograms per liter in surface runoff. During July 1988, pentachlorophenol (the active ingredient in pre-1987 fungicide solution) was found in a domestic well adjacent to and downgradient from the mill. The discharger contends that the source of this contamination is not the lumber mill.

Storm water from the mill discharges into the Shasta River 1.3 miles northeast of the mill.

16. **California Regional Water Quality Control Board, North Coast Region. 1990. Surface Water Quality Monitoring Network-Shasta River. Unpublished data.**

These data contain information on surface water quality from several stations on the Shasta River collected during 1988 and 1989. Chemical composition data includes analysis of numerous minor elements in addition to those contained in WDIS. Analyses of antimony, barium, beryllium, cobalt, molybdenum, thallium, and vanadium concentrations indicated all were below detectible limits.

Diel data collected on the morning of June 13, 1989 revealed very low dissolved oxygen concentrations at Shasta River stations located below Shastina, at Highways 3 and 96, and at the Montague-Grenada Road. The dissolved oxygen concentrations at these stations ranged from 1.7 to 3.9 mg/L. Algae and macrophyte respiration were assumed responsible for the depleted early morning dissolved oxygen concentrations. Higher pH values were present during evening samples due to photosynthetic removal of CO_2. Temperature was much higher in the evening and showed an increasing trend with downstream movement. Electrical conductivity increased substantially below the Montage-Grenada Road possibly due to agricultural return flows.

Coliform data were collected from three Shasta River stations on September 28, 1988. Very high fecal coliform levels were present at all three stations (240 to 1,600 colonies per 100 ml). The highest concentrations of fecal coliforms were present at the Highway 3 station. Both upstream and downstream coliform levels were lower.

17. **Ouzel Enterprises. 1990. Shasta River Water Quality Data.** Unpublished **data.**

These data were collected weekly at seven stations on the Shasta River from April 3 through May 1, 1990.

Unseasonably high stream temperatures and very inconsistent flows were apparent. On May 1, 1990 all seven stations exhibited temperatures above 60° F and ranged as high as 67° F. On this same date, two stations had dissolved oxygen levels below 5.0 mg/L and five stations had pH values in excess of 8.5. Electrical conductivity values generally showed an increasing trend with downstream flow.

Chemical composition was determined using techniques which are not approved by the EPA. A nitrate value of 4.0 mg/L was recorded at one station and ammonia concentrations in excess of 2.5 mg/L were present in 21 percent of the samples collected. These nutrient data are dissimilar to historic Shasta River WDIS data and may represent either effects of the drought or differences in analytical precision.

18. **Piemme, Neill and Bryan Inc. 1973. City of Weed and Shasta Sanitary District Project Report.** Joint Water **Quality** Control Projects.

In response to the 1971 Interim Water Quality Control Plan for the Klamath River Basin, both the City of Weed and Shastina Sanitary District were issued Water Reclamation orders by the North Coast Regional Water Quality Control Board. Both communities' waste discharge treatment facilities had been discharging directly into Boles and Beaughan Creeks during the non-irrigation season. Both streams provide freshwater fish habitat and water based recreation. The discharges contained visible amounts of algae, coliforms, low dissolved oxygen concentrations, and probably high phosphates and nitrates as well.

The recommended alternative included winter storage of wastewater from both facilities in a reservoir. Stored waste water was to be used to irrigate forage and fodder crops during the irrigation season.

19. **U. S. Geological Survey. 1970. Water Temperatures of California Streams - North Costal Sub-region. Open** file **Report.**

This report contains a summary of stream temperature data collected at four Shasta Valley stations from 1950 to 1968. The stations monitored include Shasta River near Weed, Shasta River near Edgewood, Little Shasta River near Montague, and Shasta River near Yreka. The source of these data include both U.S.G.S. and DWR grab samples.

Records based on 31 temperature measurements from the Shasta River near Weed indicate that mean monthly temperatures exceed 60°F during July, August, and September. Mean monthly temperatures below 38°F occurred only during January.

Monthly mean temperatures at the Shasta River near Edgewood based on only 10 records indicate mean stream temperatures exceed 60°F from May through September.

Temperature data collected at the Little Shasta River near Montague (49 records) indicate mean monthly temperatures exceed 60°F only during July and August. Maximum temperatures exceed 60°F from May through September. Mean monthly temperatures below 38°F occur from November through March.

Approximately 260 records are available for the Shasta River near Yreka. Monthly mean temperatures exceed 60°F during June through September. Maximum monthly means occurred in August (75.2°F). The maximum temperature recorded at this station was 87.8°F. All monthly mean temperatures exceeded 38°F. However temperatures as low as 32°F have occurred.

20. U. S. Geological Survey. 1974. **Limnological Study of Lake Shastina, Siskiyou County, California. USGS Water Resource Investigation No. 19-74.**

This limnological survey of Lake Shastina was conducted from August 1971 through September 1972. Six sampling locations including three on the lake, one on each of the two major tributaries and one station at the outflow were monitored. Water chemistry, dissolved oxygen and temperature profiles, bottom sediment chemical composition, phytoplankton, zooplankton and lake sediment benthic samples were collected, analyzed and reported.

Study results indicated thermal stratification from June through August. While supersaturated dissolved oxygen levels were present in the epilimnion, little or no dissolved oxygen existed in the hypolimnion during stratification. Vertical stratification of carbon dioxide, carbonate, bicarbonate, pH, nitrogen and phosphorus occurred in the epilimnion during thermal stratification. Elevated levels of orthophosphates, total phosphorus and total nitrogen were present in the hypolimnion during thermal stratification.

Thirty-three algal species were identified with green algae and diatom groups the dominant types. Green algae populations were relatively stable throughout the study with an average population of one million cells per liter. Diatom populations fluctuated substantially whenever blooms of Frigillaria crotonensis occurred. Blue-green algae were present only in spring samples where they reached concentrations of five million cells per liter.

21. U. S. Geological Survey. 1985. **A Water Resources Appraisal of the Mount Shasta Area in Northern California. Water-Resource Investigation Report 87-4239**

This report presents little water quality information about the Shasta Valley. It does present some hydrologic data on the Shasta Valley not found elsewhere.

The floor of the Shasta Valley (250 square-mile) contributes little runoff due to local depressions and the porous nature of the soils and basalt.

Streams entering the Shasta Valley generally decrease in discharge with distance from the mountains. These streams do not maintain a flow across the lava and alluvium to the Shasta River due to their porous nature.

Streams located in the Shasta Valley generally have low average daily mean and peak discharges per square mile (0.2 $ft^3/S/mi^2$). This low discharge is related to the low rainfall and high infiltration rates.

22. **U. S. Geological Survey. 1986. Water Resources Data for the Mount Shasta Area Northern California. Open File Report 86-65.**

This report contains water quality information on Lake Shastina and Big Springs. Two stations, one at the dam and another at the upstream end of Lake Shastina, were sampled. Big Springs was sampled for flow only. Big Springs Creek waters were sampled for physical water quality parameters, minerals and nutrients.

Lake Shastina waters were well mixed with vertical composite samples nearly identical between the two sites. pH values of 8.7 and 8.8 were identified at the dam and the upstream station, respectively. Magnesium was the dominant cation (22 mg/L) at both stations. Nutrient data indicate that relatively high (0.79 to 0.90 mg/L) total organic nitrogen concentrations were present and little or no dissolved nitrogen was present. These data indicate that almost all the organic nitrogen is tied up in algae and little is available for further green algae production. However, at the same time a relatively high amount of dissolved orthophosphates were available. These conditions favor production of nitrogen-fixing blue-green algae species.

Big Spring Creek waters had relatively low pH (6.1) and low temperature (11°C) compared to those normally found within Shasta Valley streams during September.